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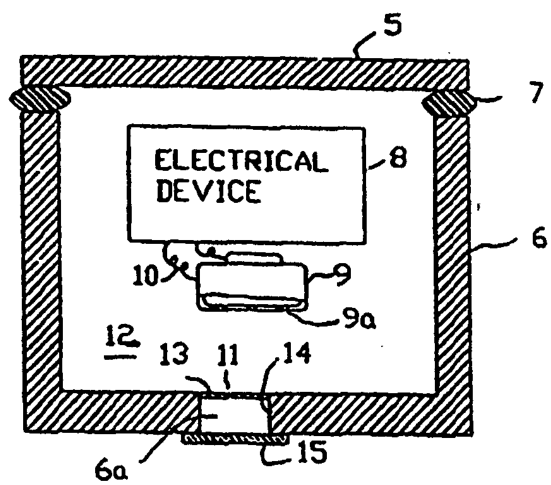
(54) Title: CONTAINER FOR ELECTRICAL DEVICE UTILIZING A METAL AIR CELL

(57) Abstract

A water resistant case (6) for an electrical device such as an electric wristwatch movement powered by a standard high current zinc/air cell. A small aperture (11) in the case wall slows ingress and egress of water vapor to the case so as to increase cell life. The aperture also limits the rate of oxygen flow to the cell cathode rather than the air entry ports in the cell itself. A hydrophobic gas transmissive membrane (45) admits air and water vapor to the aperture without admitting liquid water.



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CONTAINER FOR ELECTRICAL DEVICE UTILIZING A METAL AIR CELL

This invention relates to a container for an electrical device powered by a metal air cell and designed for low average current operation, but which intermittently requires high current. An example would be a wristwatch case which contains an electronic watch movement powered by a zinc air cell and requiring a continuous low current to operate the watch for timekeeping operation, but which includes means to illuminate the timepiece when a push button is pushed, or to operate a radio receiver as in a paging device. These latter devices require a relatively high current during the brief time when they are operating and hence a high current cell is needed to support them.

Metal air cells are well known in the art, these generally comprising a consumable metal anode, a catalytic nonconsumable, oxygen-consuming cathode, and a suitable electrolyte. Metal air cells have been manufactured in the form of miniature button cells for hearing aids and watches and the like. A typical zinc/air button cell generally includes the following components:

1. A cathode can which includes at least one aperture for entrance of air and which contains a nonconsumable air cathode structure usually comprising a gas permeable hydrophobic polymer film onto which is pressed a metal current collection grid and a waterproof, porous catalyst material such as metal catalyzed activated carbon admixed with a hydrophobic binder. Although actually an independent component of the cell, one or more electrolyte-absorbing separator layers are placed on the catalyst layer of the cathode structure to separate it from the anode.

2. An anode can which is joined to the cathode can typically by crimping and which includes a zinc anode mass typically in the form of amalgamated zinc powder (e.g., containing 3 - 8 w% Hg) or of a porous zinc compact, saturated with an alkaline electrolyte such as a 30 - 40% aqueous solution of KOH.

3. A polyethylene, polypropylene, nylon, etc. insulator between the cathode and anode can which insulator also functions in many cases as an electrolyte seal.

Control of the admission of air to the air-consuming electrode is provided by small holes in the button cell container as illustrated in U.S. Patent No.; 3,897,265 issued July 29, 1975 to Jaggard. Such cells are suitable for relatively high current drains such as 10 milliamperes which are used in hearing aids. Subsequently, zinc/air cells have been developed for long life, low current drain, as required in electric wristwatches by adding a special membrane to control the admission of oxygen to the air-consuming catalyst. One such type is known in U.S. Patent No. 4,105,830 issued August 8, 1978 to Kordesch which is permeable to oxygen. Another approach is shown in U.S. Patent 4,118,,544 issued October 3, 1978 to Przybyla et al. using very tiny pores or passages through a barrier to the cathode.

In all of the foregoing constructions, the means for controlling the admission of oxygen to the cathode is tailored for a specific application or range of current drain expected to be encountered by the cell. The foregoing constructions do not lend themselves to alternate operation of the cell in either a low average current mode or a high current mode.

Prior art teaches that the ingress and egress of gases such as air or water vapor, into and out of a zinc/air battery, can be slowed by restricting the opening(s) in the walls of the cell required to allow entry of air to the

cell. Control of relative humidity is especially important for extending cell life. A zinc/air cell will dry out in a low humidity atmosphere and Rood in a high humidity condition. Both conditions prevent the full rated capacity of the cell from being realized over a longer period of time and are especially significant at low average drain rates, i.e. in cases where the rated capacity would not be depleted in six weeks or less. The initial concentration of the battery electrolyte establishes the internal relative humidity (RH) of the cell at approximately 58%. Exposure of the activated cell to ambient RH levels, more or less than this value, causes ingress or egress of water vapor, respectively. Ingress or egress of water vapor can be restricted by reducing the size of the air admission holes. But the opening that restricts transfer of water vapor also limits transfer of oxygen to the cell. The opening in a high current cell must be sized to accommodate the oxygen ingress necessary to sustain the maximum rate of discharge.

Metal air cells having a high current drain capacity, such as those used in hearing aids, are unsuitable for use in wristwatches without modification. Metal air cells have been modified for use with electrical devices requiring a normal low average current drain with intermittent requirements for high current drain. Examples of such modification are seen in U.S. Patent 4,262,062 - Zatsky issued April 14, 1981 assigned to Applicant's assignee, and in U.S. Patent 5,451,473 Oltman et al. issued September 19, 1995. In the latter patent, a metal air cell includes a restrictive membrane controlling the flow of air from air entry ports in the bottom of the cell into an internal air reservoir. The air reservoir provides sufficient oxygen to the cathode assembly during short periods of high current drain upon the cell.

Another means for matching the cell to the electrical device receiving energy from the cell is shown in U.S. Patent 5,191,274 issued March 2, 1993 to Lloyd et al. In this patent, the number of air admission or supply holes to the cell are controlled by a seal which determines the number of holes or ports which are activated to admit oxygen to the interior of the cell. In all of the foregoing prior art, the design of the metal air cell itself determines the flow rate of air to the cell.

It is also known in the prior art to place an electrical device and a metal air cell which is designed to match the current requirements of the electrical device in a container. Since the cell requires a supply of air to operate, the container cannot be hermetically sealed. The prior art has allowed a generous supply of air to the container to satisfy the current requirements of the electrical device under all conditions. This admission of air with accompanying water vapor permits the relative humidity within the container to fluctuate widely as determined by many factors such as variations in the ambient relative humidity outside the container, temperature variations of the container and depletion of oxygen by the cell. However, water in liquid form may also enter the container through the air entry passages if the device is subjected to excessive moisture or intended for operation underneath water. It is known to utilize hydrophobic gas permeable membranes in the container walls, which admit air without admitting water in the liquid state. An example of such a housing for an instrument is disclosed in U.S. Patent 4,292,681 issued September 29, 1981 to Kloss et al. The Kloss patent discloses a container for an electrical device having a lid and a seal, in which either the seal itself, or an aperture in the lid, or the housing itself may be composed of a hydrophobic, gas permeable, microporous substance.

Referring to **Fig. 1** of the drawing, a prior art container for an electrical device is depicted in U.S. Patent 4,292,681 to Kloss. The housing consists of portions **1** and **2** in which the housing portions are connected in water-tight manner to each other by means of a non-gas transmissive sealing ring **3**. The portion **2** which takes the form of the housing lid is provided with a gas passage **4**, which is closed by a microporous, hydrophobic component. The air oxygen elements (electrical device and metal air cell) which are housed within the enclosure are supplied with air through this component which may, for example, be made of unsintered polytetrafluoroethylene. It is also possible to provide several such air transmissive apertures, closed off by microporous sealing bodies. By way of example, the zinc/air cell contained within the housing utilizes about five microliters of air per hour. In the event of immersion in water, the watch continues to run utilizing the air contained within the housing.

The zinc/air cell described in the aforementioned prior art must be especially adapted for a wristwatch, if it is to have any useful practical life, by means of air flow restrictive membranes inside the cell or by similar devices such as those described in the aforementioned U.S. Patents 4,292,681; 5,191,274 or 5,451,473. In the Kloss patent, the use of such a hydrophobic, gas permeable material (usually in the form of a membrane) is for the purpose of restricting the ingress of water in the liquid state without attempting to substantially restrict the rate of ingress of air or other gases, including water vapor.

Accordingly, one object of the present invention is to provide an improved container for an electrical device powered by a metal air cell which will extend the life of the cell.

Another object of the present invention is to provide an improved container for extending the life of a high current capacity metal air cell supplying energy to an electrical device having low average current requirements.

Another object of the invention is to provide an improved container for controlling the changes in relative humidity experienced by a metal air cell inside the container.

Another object of the invention is to provide an improved process for utilizing a standard zinc/air high capacity cell of the hearing aid type to power a wristwatch movement contained in a water-resistant case.

SUMMARY OF THE INVENTION

Briefly stated, the invention comprises a container for controlling the rate of ingress and egress of air and water vapor to a high current metal air cell supplying energy to an electrical device having low average current requirements and intermittent high current requirements, the metal air cell and the electrical device both being disposed in the container with the metal air cell having air entry ports sized to admit a flow of oxygen substantially in excess of that necessary for the cell to supply the low average current requirements of the electrical device. The container comprises a sealed housing defining an air reservoir containing the metal air cell, the sealed housing having a wall defining a restricted flow passage communicating between the air reservoir and the atmosphere outside the housing and sized to admit flow rate of oxygen only sufficient to satisfy the low average current requirements of the electrical device. In its preferred form, the housing further includes a hydrophobic gas permeable membrane disposed between the restricted

flow passage and the atmosphere outside the housing and adapted to block entry of liquid into the housing while admitting flow of oxygen to the restricted flow passage. In the preferred embodiment, the restricted flow passage is a tiny hole in the container wall having a diameter of approximately .08 mm (.0032 inches) which is supplied from an aperture covered with a GORE-TEX® membrane. Alternatively, any other material having hydrophobic gas transmissive or gas permeable proper ties can be used.

DRAWINGS

Other objects and advantages will better be understood by reference to the following specification, together with the accompanying drawings, in which

Fig. 1 is a simplified diagrammatic elevation view in cross section of a prior art container for an electrical device,

Fig. 2 is a simplified diagrammatic elevation view in cross section of a housing for an electrical device and energy cell in accordance with the present invention,

Fig. 3 is a similar view illustrating a modified form of the invention,

Fig. 4 is a similar view illustrating a further modified form of the invention,

Fig. 5 is a similar view illustrating a further modified form of the invention, and

Fig. 6 is a similar view illustrating a further modified form of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The container according to the present invention, in its simplest form, is illustrated in simplified diagrammatic form in **Fig 2**. A sealed housing is provided by means of portions **5** and **6** connected in watertight manner to each other by means of a non-gas transmissive sealing ring **7**. Disposed inside the housing is an electrical device **8**, which requires supply of electric energy from an energy cell **9** connected electrically thereto by leads **10**. Since the figures of the drawing are shown in simplified diagrammatic form, no mechanical structure or supports are shown for electrical device **8** or **9**, it being understood that these are required. Electrical device **8** is intended to represent a device such as an electric watch movement or electric instrument which requires a continuous low current flow for timekeeping in the microampere range (2 to 250 microamperes) and also periodically or intermittently requiring high current flow in the milliampere range (2 to 12 milliamperes). An example is an electric pager wristwatch which consumes a steady current of around five microamperes to operate the timekeeping functions, but which intermittently requires a relatively high current on the order of 10 milliamperes to operate the pager. Since the pager is operated only occasionally, the average current drain is low.

The energy cell **9** is a standard high capacity or high current flow zinc/air cell such as used in hearing aids, for example cell number 13 or number 675 which is commercially available but which has not been modified to restrict the air supply to the cathode structure by one of the previously discussed schemes. As such, the high current zinc/air cell **9** is designed to have a useful life only on the order of three to six weeks after being activated by removing the covers to its air entry ports shown as **9a**.

All cells of this type are sensitive to changes in relative humidity and other atmospheric conditions which may alter the chemistries in the cells causing battery degradation and premature energy depletion. In a low humidity environment, moisture evaporates from the electrolyte and will escape from the cell, decreasing the volume of electrolyte and ultimately causing desiccation. In high humidity, the cell will be caused to gain water which has the effect of diluting the electrolyte and eventually flooding the cell. In this case, the dividing line between "low" humidity and "high" humidity is an equilibrium value of relative humidity which the cell tries to maintain by its internal chemistry, of about 58% relative humidity. Above 58% relative humidity, the cell takes on water and below 58% relative humidity, the cell loses water. The gains and losses of water are enabled by diffusion of water vapor into and out of the air entry ports **9a** in the wall of the cell.

Air also flows into the cell **9** through air entry ports **9a** and the oxygen is consumed by reaction with water to produce hydroxide ions. Examples of number and size of typical air entry ports in typical commercially available high current zinc/air cells hearing aid cells are given in the following table:

		Hole Size Diameter		Total Flow Area	
Cell	No. of Holes	mm	(Inches)	mm^2	(in^2)
A	4	.51	(.020)	.82	(0013)
B	2	.46	(.018)	.33	(.0005)
C	6	.28	(.011)	.37	(.0006)

The flow of oxygen which would be admitted through the air entry ports above is substantially in excess of that necessary for the cell to

supply low average current requirements of the electrical device in the microampere region, but is sufficient to supply momentary high current requirements of the electrical device on the order of a few milliamperes.

In accordance with the present invention, the ingress and egress of water vapor and the ingress of air (oxygen) for sustained low average current requirements of the electrical device are controlled by means of a restricted flow passage **11**. Passage **11** communicates between an air reservoir **12** inside the housing and the ambient atmosphere outside the housing. In the embodiment depicted in **Fig. 2**, the restricted flow passage comprises a tiny hole drilled or formed by laser in a metal plate **13**. Plate **13** is sealed or otherwise supported within an aperture **14** in the wall of housing portion **6**. A suitable size of the restricted flow passage **11** to support a low average current drain of 2 milliamperes is a small single hole with a diameter of .08 mm (.0032 inches), or a flow area of .005 mm2 (.000008 in2). A useful range of hole diameters for a restricted flow passage **11** is between 0.05 mm and 0.1 mm, depending upon the expected low average current drain. This diameter can be calculated or determined empirically. The flow of air through a hole of this size into air reservoir **12** is sufficient to satisfy the low average current requirements of the electrical device **8** on a sustained basis. However, we have discovered that the hole also substantially impedes and slows down the diffusion of water vapor into and out of air reservoir **12**, and substantially lengthens the useful life of the metal air cell. In the event of blockage of the hole or in the event of high current drain requirements on the part of electrical device **8**, reservoir **12** supplies the needs of cell **9** for a short time.

Referring to Fig **3** of the drawing, another embodiment is shown, in which the same elements are indicated by the same reference numbers

as in **Fig. 2**. However, in this case, the plate **13** with its restricted flow passage **11** is located toward the inside of aperture **14** and the outside of aperture **14** is closed off with a hydrophobic gas transmissive element comprising a membrane **15**. Membrane **15** is preferably a foil of unsintered polytetrafluoroethylene. One suitable membrane **15** commercially available under the brand name GORE-TEX@, which permits air and water vapor to permeate but inhibits passage of water in a liquid state. The membrane **15** covers aperture **14** and is supported and sealed around its edges on the container wall. A chamber 6a in the wall of housing **6** between hole **11** and membrane **15** collects air and water vapor which passes through the pores of the membrane. Membrane **15** is not designed to appreciably restrict the flow of air to the air reservoir **12**, this function being accomplished by the restricted flow passage **11**. The size of the aperture is selected so that the flow of air through membrane **15** is sufficient to satisfy the low average current requirements of the electrical device. However, membrane **15** assures flow of sufficient air to chamber **6a** without permitting the entry of water in liquid form so that continuous operation of electrical device **8** can continue in inclement weather. In the event of complete immersion of the housing in water, cell **9** is supplied with air from reservoir **12** for a substantial length of time under low current drain requirements. In the event of momentary high current requirements, cell **9** is likewise supplied for short periods of time from air reservoir **12** surrounding the cell. Since water vapor is a gas, it too will pass through membrane **16**. Its rate of ingress or egress by diffusion is greatly slowed by the combined action of the membrane and the restrictive flow passage **11**.

Referring to **Fig. 4** of the drawing, a modified housing portion **16** is shown having a lid **5** and sealing ring **7** as before. Inside the housing is

a battery compartment wall **17** which defines a battery compartment **18**, serving as an air reservoir surrounding cell **9**. A removable battery cap **19** provides access to the battery compartment **18**. Cap **19** is provided with a sealing gasket or O-ring **20**, and may be attached to housing **16** by a bayonet lock or screw threads or any suitable method. Cap **19** defines an aperture **21**. Sealed within aperture **21** on the inner side facing the battery compartment is a plate or washer **22** with a restricted flow passage **23** similar to that previously described for restricted flow passage **11**. Covering the aperture **21** facing the atmosphere is a gas transmissive hydrophobic material in the form of membrane **24**, which may be identical to that described above in **Fig 3** by reference number **15**. A chamber **19a** collects air and water vapor which passes through the membrane **24**.

Fig. 4 is representative of constructions often found in an electric watch, where the electrical device is in a compartment separate from the energy cell, the latter being removable through a separate aperture by means of a removable cap such as **19**. Electrical leads **25** connect cell **9** to device **8** through seals **26** in wall **17**. The **Fig. 4** arrangement may be more practical in actual use, since cap **19** may be removed and the flow passage **23** and membrane **24** inspected or tested with ease, in addition to providing for normal replacement of the energy cell **9**.

Referring to **Fig. 5** of the drawing, a modification is shown which is similar in every regard to **Fig. 3**, except that the lower portion of the housing identified by reference numeral **27** is constructed of plastic material, such as polycarbonate. An aperture **28** on the outside surface of housing portion **27** connects with a restricted flow passage **29** in the interior surface of housing **27**. A suitable diameter of aperture **28** is 1.75 mm (.069 inches). As before, a satisfactory diameter for the restricted flow

passage **29** which is molded in wall at the time of manufacture, is .08 mm (.0032 inches). The drawing is not to scale, but is exaggerated for clarity of presentation. A membrane **15** of hydrophobic gas transmissive material covers aperture **28** and is supported by and sealed to the outer wall of housing **27**. An intermediate chamber **30** collects gas passing through the pores of membrane **15** as before.

Another modification is illustrated in **Fig. 6** of the drawing, which specifically depicts an electric wristwatch with a plastic case or housing **31**. While this embodiment is depicted to show the invention as applied to a watch, it will be appreciated that this can be applied to any electrical device powered by a metal air cell as shown more generally in **Figs. 2 - 5**. Housing **31** incorporates an interior battery compartment wall **32** defining a battery compartment **33**. Compartment **33** contains a pair of series connected metal air cells **34**, b. A battery access cap **36** is provided with a sealing gasket or O-ring **20** and attached to housing **31** by a bayonet lock or screw threads. An aperture **37** in the outer surface of the wall of housing **31** narrows to a restricted flow passage **38** on the interior wall inside battery compartment **33**. The dimensions of the aperture **37** and restricted flow passage **38** may be as previously described in connection with **Fig. 5**. Closing off the aperture **37** is a membrane 15, constructed and attached as previously described in connection with **Fig 5**. Membrane b admits gas into, but excludes liquid from, a chamber **39** which, in turn, supplies battery compartment **33**. Series connected zinc/air cells **34, 35** supply a watch movement **40** via leads **41** passing through the battery compartment wall **32**. Watch movement b is of conventional construction and includes operating pushbuttons and means to illuminate the watch dial when a pushbutton is operated (not shown). A suitable movement is shown in U.S. Patent 5,265,071 issued

November 23, 1993 to Thorgersen et al. and assigned to the present assignee, which is incorporated herein by reference. Operation of the pushbutton requires high current for a short period of time of approximately 6 milliamperes. Battery compartment **33** provides an air reservoir which can be preselected in volume to supply the intermittently required high current of the illumination device in movement **40** for a specified time. Restricted flow passage **38** is of sufficient size to supply the low average current requirements of watch movement **8**. Such calculations are within the scope of one skilled in the art. A transparent lens **42** is sealed to the housing **31** in order to view the time indicated on the watch movement.

The air reservoir **33** shown in **Fig. 6** is designed to be of sufficient size to operate the movement for a selected time at a selected current drain if the air path is blocked. For example, if there are two cells connected in series and if the air in the reservoir is composed of the normal proportion of 21% oxygen, 1 cubic centimeter of volume in the-reservoir (above that occupied by the cells themselves) will provide approximately 1/2 milliampere hour. Therefore, if the container is submerged in water and the movement requires a continuous current supply of 2 ma, the two cells will operate the movement for approximately 15 minutes.

EXAMPLE

A test was run under controlled conditions using a 675 hearing aid cell placed in a sealed container with an electrical device arranged to draw 500 milliampere hours over a period of four months. The container was provided with a single aperture of .08 mm diameter (.0032 inches). The relative humidity outside the container was maintained constant for

three tests over a four month period, one at 10% relative humidity, one at 90% relative humidity and the third at a relative humidity of 58% which is that maintained by the cell electrolyte. In every case, the cell performed properly over the four month period.

In a control test without the container and cell exposed, the same relative humidity conditions were maintained. At 10% relative humidity and at 90% relative humidity, the cell failed to operate after one week in each case, whereas at 58% relative humidity, the cell continued to function properly for the full test.

Thus there has been described an improved housing for an electrical device which may utilize and extend the useful life of a standard high current zinc/air cell. The housing itself controls the rate of ingress and egress of water vapor, slowing down changes in relative humidity conditions which shorten cell life. The housing also controls the rate of supply of oxygen to an air reservoir containing the zinc/air cell so as to cause it to more closely match the requirements of the electrical device. In modified form, the housing also provides the aforesaid advantages but is rendered resistant to liquids with a membrane disposed to prevent the entry of water. The membrane assures a flow of air through the restricted flow passage controlling usage of the cell inside the housing, while acting together with the restricted flow passage to reduce the ingress and egress of water vapor.

By slowing the diffusion of water vapor into and out of the air reservoir in which the cell is located, the cell life is substantially increased.

While there has been described what is considered to be the preferred embodiment of the invention and several modifications

thereof, it is desired to secure in the appended claims all such modifications as fall within the true spirit and scope of the invention.

We claim:

CLAIMS

1. A container for slowing the ingress and egress of water vapor to and from a high current capacity metal air cell connected to an electrical device having low average current requirements, said metal air cell and said electrical device both to be disposed within said container, said metal air cell having air entry ports for admitting a flow of oxygen, said container comprising:

   a sealed housing defining an air reservoir for containing said metal air cell, said sealed housing having a wall defining a restricted flow passage communicating between said air reservoir and the atmosphere outside the housing and sized to admit a preselected flow rate of air to said air reservoir sufficient only to satisfy said low average current requirements of the electrical device.

2. The container according to Claim 1, wherein the restricted flow passage comprises at least one hole in said wall.

3. The container according to Claim 1, wherein the restricted flow passage is a hole in the housing wall having a diameter between 0.05 and 0.1 mm.

4. The container according to Claim l, wherein said housing further includes a hydrophobic gas permeable member defining a chamber between the restricted flow passage and the atmosphere outside the housing and adapted to block entry of liquid into said chamber, and further adapted to admit a preselected flow rate of oxygen to said chamber sufficient to satisfy said low average current requirements of the electrical device.

5. The container according to Claim l, wherein said housing includes a removable cap for access to the metal air cell, said wall being disposed in said cap.

6. The container according to Claim l, wherein said housing defines first and second compartments for said metal air cell and said electrical device respectively, and includes a removable cap for access to the first compartment, said air reservoir being located in the first compartment.

7. A container for extending the life of a high current capacity metal air cell connected to an electrical device of the type having low average current requirements with intermittent high current requirements, said metal air cell and said electrical device both to be disposed within said container, said metal air cell having air entry ports sized to admit a sufficient flow of oxygen to satisfy the high current requirements, said container comprising:

a sealed housing defining an air reservoir for containing said metal air cell, said sealed housing having a wall defining a restricted flow passage communicating between the air reservoir and the atmosphere outside the housing and sized to admit a preselected flow of air to said air

reservoir sufficient only to satisfy the low average current requirements of the electrical device, the volume of said air reservoir being preselected to satisfy a preselected average current drain for a preselected time when the restricted flow passage is blocked.

8. The container according to Claim 7, wherein the restricted flow passage comprises at least one hole in said wall.

9. The container according to Claim 7, wherein the restricted flow passage is a hole in the housing wall having a diameter between 0.05 and 0.1 mm.

10. The container according to Claim 7, wherein said housing further includes a hydrophobic gas permeable member defining a chamber between the restricted flow passage and the atmosphere outside the housing and adapted to block entry of liquid into said chamber, and further adapted to admit a preselected flow rate of oxygen to said chamber sufficient to satisfy said low average current requirements of the electrical device.

11. The container according to Claim 7, wherein said housing includes a removable cap for access to the metal air cell, said wall being disposed in said cap.

12. The container according to Claim 6, wherein said housing defines first and second compartments for said metal air cell and said electrical device respectively, and includes a removable cap for access to the first compartment, said air reservoir being located in the first compartment.

13. A water resistant wristwatch case for use with an electronic watch movement requiring current- drain for timekeeping in the 2 to 250 microampere range and occasional supply of current in the 2 to 12 milliampere range from at least one zinc/air high current cell, resulting in a low average current drain, the watch movement and the zinc/air cell both to be disposed in said watch case, the watch case comprising:

a sealed housing defining an air reservoir for containing the zinc/ air cell, said housing having a wall defining an aperture, and a hydrophobic gas permeable membrane covering said aperture, said wall defining a restricted flow passage leading from said aperture to said air reservoir, said restricted flow passage being adapted to admit a preselected flow rate of oxygen to said air reservoir only sufficient to support continuous operation of said cell at said low average current drain, said membrane being adapted to admit a preselected flow rate of oxygen to said restricted flow passage sufficient to support operation of said cell at said low average current drain.

14. The container according to Claim 13, wherein the restricted flow passage is a hole in the wall having a diameter on the order of .08 mm.

15. The container according to Claim 13, wherein the aperture has a diameter on the order of 1.75 mm and the membrane is of GORE-TEX@.

16. The container according to Claim 13, wherein the restricted flow passage and the membrane are selected to support low average current drain on the order of 2 milliamperes.

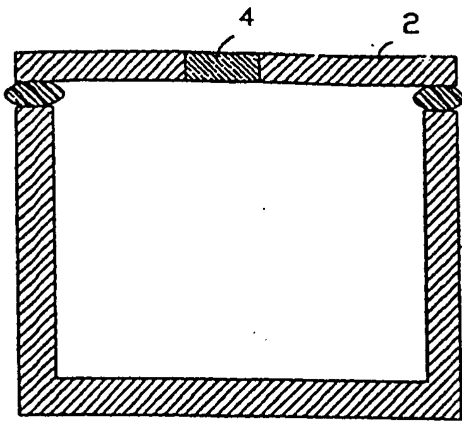

FIG. 1 (Prior Art)

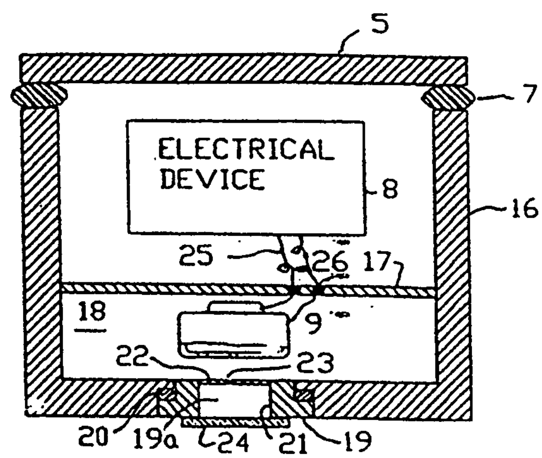

FIG. 4

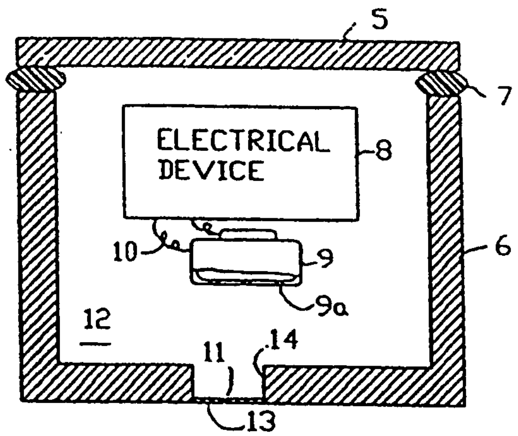

FIG. 2

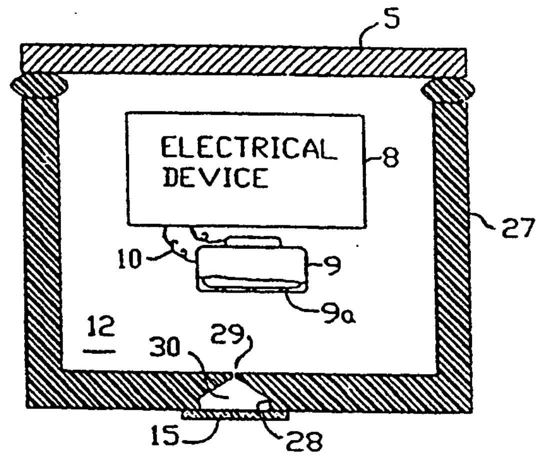

FIG. 5

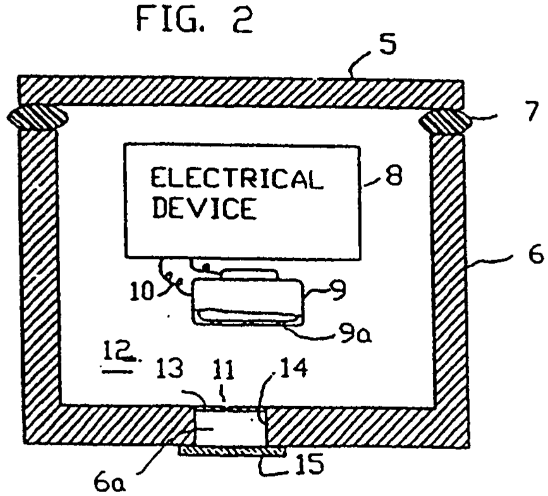

FIG. 3

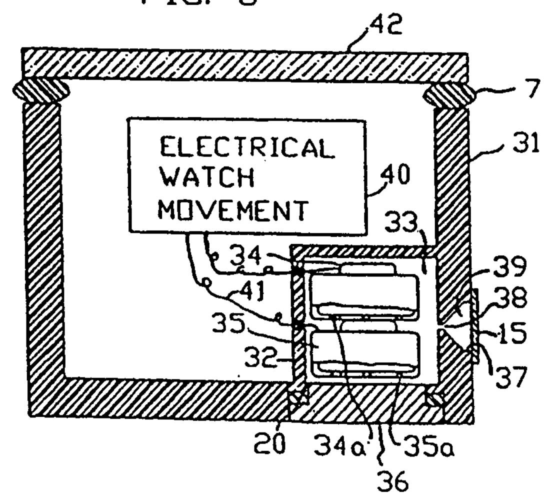

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/07328

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :HO1M 1/16, GO4G 37/00
US CL : 368/204,276
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 368/204,276,10,203,327

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,292,681 A (KLOSS ET AL)29 September 1981 (29-09-81), Figure 1.	1-16
Y	US 4,262,062 A (ZATSKY) 14 April 1981 (14-04-81), Figure 1.	1-16
Y	US 5,307,520 A (OYAMADA ET AL) 26 April 1994 (26-04-94), figure 2, A, 20.	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 JUNE 1998	14 SEP 1998

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